Chemical & Engineering NEWS

Basic petrochemicals—1963 will bring late, slow recovery
A Key Chemicals Review Page 18

A1250-1
11/23/82

0511179C093 9 W AR6047SL 1
CONGRESSIONAL INFO SERV
4520 EAST WEST HWY SUITE 800
SRI ACQUISITIONS
BETHESDA MD 20814

BEST AVAILABLE COPY

November 22, 1982
Volume 60, Number 47
CENEAR 60 (47) 1–48
ISSN 0009-2347

Chemical & Engineering NEWS

Cover: Research associate James W. McNay prepares male-sterile corn seedlings for study at the University of Florida, Gainesville. Photo courtesy of USDA's Agricultural Research Service

2 Letters

Concentrates
17 Business
24 Government
28 Science/Technology

The Departments
36 ACS Comment
48 Newscripts

News of the Week

- ***Warren D. Niederhauser*** *wins president-elect post by a margin of more than 6000 votes over his closest competitor in one of ACS's most controversial elections.* ***Page 4***
- ***Central science panel*** *urged by scientists to aid regulatory decision making by providing impartial assessments of environmental hazards risks.* ***Page 5***
- ***Terpene alcohols*** *being produced directly from α-pinene in a process that eliminates the need for large amounts of turpentine to isolate the pinene isomer.* ***Page 5***
- ***New biodegradable butyrate thermoplastic*** *may get scaleup at ICI; the plastics is metabolism product of a bacterium growing on variety of starches and sugars.* ***Page 6***
- ***Ethics of genetic engineering*** *concern Presidential commission; oversight panel recommended to review ethical implications of genetic research.* ***Page 6***

News Focus

- ***Agricultural research*** *due for a shakeup; criticism leveled at the present system spotlights changes needed in the Agricultural Research Service and problems stemming from higher costs of farming.* ***Page 8***

Business

- ***Major petrochemicals*** *begin to inch their way toward higher production levels and better financial health after a low point in output this past summer.* ***Page 18***

Government

- ***Implication of acid rain*** *in northern Vermont forest dieback may lead to more-stringent proposals from lobbyists for acid rain legislation.* ***Page 25***

Science

- ***Nervous system's chemical complexity*** *found to be far greater than imagined; new findings give insights into how nerve cells transmit signals.* ***Page 29***
- ***Key step in the biosynthesis*** *of the steroid lanosterol uncovered by researchers at Stanford University.* ***Page 32***

Books

- ***"A Higher Form of Killing:*** *The Secret Story of Chemical and Biological Warfare" by Robert Harris and Jeremy Paxman is chemical warfare primer.* ***Page 34***

Shakeup ahead for agricultural research

Reorganization of Agricultural Research Service is under way, triggered by charges that research hasn't kept pace with resource depletion and high costs of farming; fight seen over Hatch Act research funds

Wil Lepkowski
C&EN, Washington

A bounty of reports and studies the size of a Thanksgiving feast has streamed from official circles and various think tanks over the past two years. They all say U.S. agriculture is in deep crisis, that it is in need of a revolution in research perhaps as vast as that begun by the epic organic chemist Justus von Liebig, who brought chemical science to farming more than a century ago.

The reports range from a big study of the Department of Agriculture's research bureaucracy by Congress' Office of Technology Assessment to "Empty Breadbasket," a critique by the Cornucopia Project of Rodale Press. That report says each state should be developing a policy of food self-sufficiency in the face of mounting national problems.

One could make after-dinner frolic by assigning to each study the metaphor of mashed potatoes, peas, or pumpkin pie. The turkey, however, would by all odds be "Science for Agriculture," issued by the White House only a few weeks ago. This is more commonly known as the Winrock report after the conference center in Arkansas where it was spawned at a meeting last summer.

Turkey, of course, has opposing connotations—one pejorative, the other gastronomic. And so it is with the Winrock document. The agricultural research establishment in the land grant universities thinks the report is very much a turkey, but the establishment, nonfarm research community is pleased as punch with it. It says among other things that the research at the land grant schools is outmoded and out of phase with today's exciting developments in plant biology. It says that more scientists should have access to that $650 million in agricultural research money that goes directly to universities from states and the federal government. It also says that the Agricultural Research Service (ARS) with its 148 laboratories, 2700 researchers, and $426 million budget does a lot of unnecessary research and needs a wider sense of vision in its perspective on agriculture's problems.

Whether the criticism is really deserved is legitimate grounds for debate. But what everyone appears to agree on is that U.S. agriculture is headed for trouble without a major reform of some kind. Critics say the agricultural system no longer is energy and resource efficient, and thus not geared to relieving the ecological and economic threats endangering the land, the crops, and the farmers that husband them. Bigger and increasingly expensive machinery, rising energy costs, coupled with inflation and high interest rates are sinking farmers deeper and deeper into debt. Meanwhile, the land is eroding when it isn't being contaminated by salt from irrigation runoff. One-species cropping is raising the risk of disease infestation. And the traditional American small farm, the type shown by research to produce most efficiently while retaining soil quality, is fading into history.

At the same time, a revolution in biological research is occurring—one that promises to transform the industries that serve agriculture, and thus, eventually, farming. The innovators are companies like Monsanto, Stauffer Chemical, Dow Chemical, Eli Lilly, Rohm & Haas, Merck, and Du Pont. Each is in the business of selling new products and services to modern farmers and cattlemen. Many of these corporations, through links with top geneticists, biochemists, and molecular biologists in universities in the U.S. and, increasingly, abroad are sowing the seeds for what they hope will be a new industrial revolution in agriculture.

The manipulation of genes has already produced a hoof-and-mouth vaccine to immunize cattle, and a bovine growth hormone to increase milk and meat production. "Genetically engineered soil bacteria to produce fertilizer or to control pests may be possible," says John Marvel, Monsanto's general manager for research. "Within the next 10 to 25 years, we hope to induce plants to be resistant to pesticides, immune to disease, tolerant of hostile environments such as heat, cold, and brackish water, and capable of producing more protein."

But sitting off to the side (some harsher critics would say dozing) are the agricultural experiment stations in the 50 land grant universities. These institutions were established under the Morrill Act of 1860 and

receive federal formula funding under the 1887 Hatch Act. Last year Congress appropriated $221 million in Hatch Act funds while the states chipped in with $500 million more. Most of the new agricultural horizons have brightened, they say, not because of much fundamental research conducted by those institutions but through research supported by nonagricultural agencies such as the National Science Foundation and National Institutes of Health. The critics contend the system needs a shaking up and a revival.

The Cooperative State Research Service (CSRS), USDA's agency that administers these Hatch Act funds, is little more than a faceless, policy-neutral entity to those outside its own 50-state granting system. Yet, these same land grant schools have worked closely with farmers and agribusiness as an effective team.

Moreover, no one wants to wreck something that already is the envy of the world. And no one really wants to end any creative research duplication between USDA's two separate systems of research. But the problems ahead are so vast and expensive that the debate over how to breed a sense of vision into the system could last for years, because not everyone wants to change the same way.

On production data alone, the system—America's largest industry with an asset value of almost $1 trillion—is certainly working. Thanks to the power and creativity of agricultural research and technology—mainly through the fruits of a half century of developments in chemistry and mechanical engineering—this year's harvest of corn, wheat, sorghum, and soybeans is the most abundant on record.

But these crops, plus cattle and hogs, also are selling at record low prices. The economy is so depressed that farmers cannot sell enough of that surplus. When farmers overproduce, prices fall. When prices fall, farmers go more deeply into debt. With deeper debt, more farms fail. USDA predicts that as many as 7% of the country's farmers could go bankrupt this year. And as farmers relay their plight to Washington, the agricultural chemicals industry echoes misery of its own in its 10% drop in sales this year. "There is real concern that next year will be worse than this year," says Jack Early, president of the National Agricultural Chemicals Association.

But there is another form of agricultural economics that the big business of agriculture and the research system that supports it tend to play down. It is this aspect of agriculture—the sustainability, or ecological, factor—that research just recently has gotten around to noticing. It lies in such facts that only 150 separate plant species are involved in food commerce today, versus 5000 at the dawn of agriculture, or that soil is eroding at catastrophic rates in some parts of the country. Is modern agricultural research, built on an industrial production model, therefore destroying the necessary balance between ecology and land husbandry? Or does nature have more resilience than environmentalists and conservationists think? And beyond that, what role does chemical technology and industry have to play in that revival? Will U.S. culture lose that nebulous but nevertheless crucial sense of roots if its agrarian tradition vanishes?

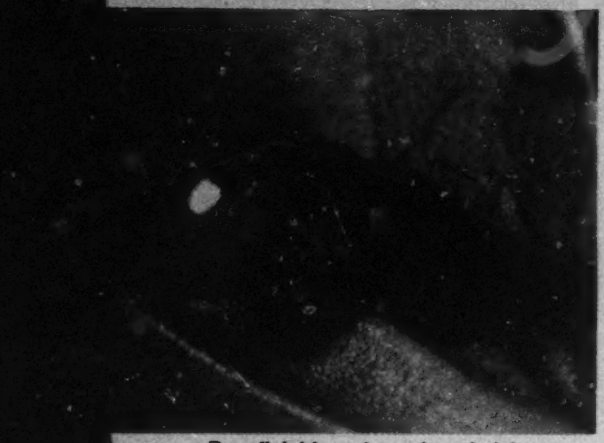
One trouble is that the agricultural research establishment has only half-heartedly probed for answers, built as it is on the large-scale industrial model of mechanical and chemical inputs. A few voices from the environmental, land policy, and organic farming communities were raised during the 1970s, but, except for a period during the Carter Administration, they seldom reached the chambers of official policy either in the states or in Washington, D.C. But they are rising again, and one of the places leading the alternative dialogue is the Rodale Organic Farm Research Center in Emmaus, Pa. This center is funded almost totally by Rodale Publishing Co. and does sophisticated studies of large- and small-scale uses of natural methods of raising yield and controlling crop disease. Another such focus of alternative thought is the Land Institute in Salina, Kan. This privately funded research center, directed by Wes Jackson, studies nonchemical methods of agriculture based on germ plasm derived from disease and stress resistant species of plants native to the Kansas prairie.

"The changes in agriculture over the next 10 years will be greater than those that took place during the past 30 to 40 years," says Richard Harwood, director of the Rodale Center. "We are approaching the end of several frontiers involving cheap water, labor, capital, and energy. And all these are having a powerful impact on farmers. Most farmers with less than a thousand acres will be hurt under these pressures. So we're going to have a dislocation over the next decade or two until we come to a new equilibrium, just as we're reaching a new equilibrium in capital investment."

Harwood believes the rising price of natural gas will transform agriculture irreversibly. "Since 1972," he says, "the price of agricultural nitrogen has gone from 3 cents a lb to 25 cents. The Fertilizer Institute says that by 1986 the price will go up to $1.00. By the 1990s, natural gas no longer will be a source of nitrogen fertilizer."

Harwood says that at 25 cents a lb, it already is cheaper for the farmer to produce his own biological nitrogen by spreading legumi-

Some scientists continue to push their traditional priority for higher crop yields (left), while other scientists try to halt massive erosion problems (above)



Beneficial insects such as ladybugs can replace some chemicals in controlling diseases afflicting crops

nous plants on his fields between seasons. In Delaware, 140,000 acres already are being fertilized with a cover of vetch over the winter. "So we already have passed the threshold there," he says. But Delaware has good soil and rainfall, so it may not be representative of opportunity where the farm belt is concerned. "What the threshold is out there, I don't know," Harwood says, adding that in neighboring Maryland, county agents are opposed to vetch, claiming that it will cause a weed problem.

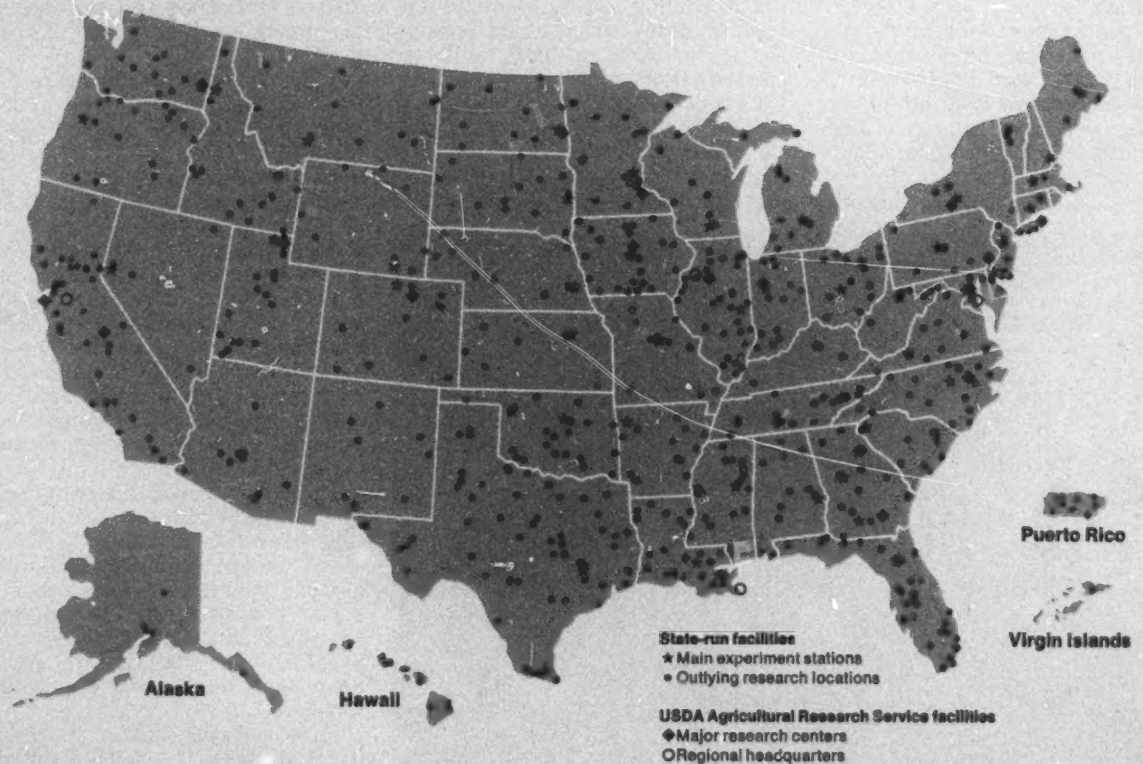
Still, the questions are all part of the transition. What Harwood asks is whether the Agricultural Research Service is aware of the problems coming up and whether it is mounting research on, say, dryland cropping through development of new seed varieties that can tolerate dry conditions. "Moreover," he adds, "are the seed companies foreseeing these problems? Similarly, are the pesticide companies shifting over to biological control research, given the disruptive effects of these agents on the soil?" The answer, of course, is yes, or at least somewhat. Both ARS and the various land grant university agricultural experiment stations have programs in integrated pest management. And, as Monsanto's Marvel points out, seed companies are applying genetic engineering to breed in resistance into chromosomes of important crops.

Edwin M. Wheeler, director of the Fertilizer Institute in Washington, D.C., quite expectedly thinks the natural approach to agriculture is hokum and offers no solution to the farm energy crisis. "This country would starve to death if we went to organic farming," he says. But he does agree with Harwood that natural gas prices will soar once deregulation goes into effect. And to him, the only answer is bigger production for the grain export markets of Japan, U.S.S.R., and China, which are ready with the cash. What Wheeler fears, however, are the developing countries where natural gas is freely flared for lack of ammonia plants to capture it.

"If prices get too high in the U.S.," he says, "these countries would be tempted to produce ammonia." Coal-based sources of methane through big synthetic fuel plants could be an answer, he says, "but you're talking about tons of money to build one of those plants. Still, if you're talking about a U.S. nitrogen industry beyond 1990, it will have to be based on coal." As for the production outlook for U.S. agriculture, Wheeler says the key is exports. "The U.S. fertilizer industry and U.S. farming are absolutely dependent on them. It boggles the mind what this country can produce."

That sounds like a lot of pressure on the system of highly technological,

Government-run agricultural research forms a vast network



Source: Department of Agriculture

highly chemical agriculture. But whatever the doubts about the advantages of capital-intensive agriculture, these trends are inevitable, according to Barry Richmond of Dartmouth College's Resource Policy Center. Richmond is conducting a study sponsored by Caterpillar Tractor on the trends in the agricultural system over the next 50 years. Caterpillar's interest, of course, is to forecast some of the farm machinery markets that will develop over that time. The key finding so far, Richmond says, is that soil erosion problems are leading toward the widespread practice of no-till or minimum-till agriculture. Instead of plowing the soil every spring, many farmers now draw narrow trenches up and down their fields and apply seeds, fertilizer, pesticides, and herbicides.

"We believe," he says, "agriculture is being governed by an ethic that is seeking to gain control over the entire system. Today, the family farm doesn't have much control over anything. Not only do farmers have no control over the weather, but they're also at the total whim of the grain merchant. Thus, they can't control the price of their product. And what is going on in the evolution of agriculture is the increasing aggregation in the farm sector. Ownership is getting more and more concentrated. And that kind of evolution is controlling what's getting done to the soil.

"I don't think there's a chance in the world that the system can go back to smaller farms, just as we can't go back to horses and buggies," he says. "The system is going back to no-till agriculture because of two forces: soil erosion and energy prices. Of course, the drawback to no-till farming is the danger of the buildup of pests in the soil. When you don't turn the soil over and leave a crop cover over it, the soil forms an excellent breeding ground for pests. So our guess is that a hybrid form of no-till agriculture will develop, combining till and no-till.

"But what is sure is that no-till will accelerate the trend toward corporate aggregation because no-till requires very sophisticated management. You simply must know a lot about the soil in that kind of agriculture, and that will take sophisticated computer-based management. You have to do a lot of things within a narrow weather window. If you miss that, you're dead because of the very delicate orchestration needed between pest management and fertilizer application. No-till takes a much greater application of pesticides and herbicides.

"What all this means for the ecology is tough to tell. Some chemicals like Paraquat bind to the clay in the soil, which is tantamount to mining the soil. When bound that way, the soil is no longer useful for purposes such as aggregation and pore space. This causes an inherent breakdown in the structure of the soil. Also, these chemicals could leach into the ground water."

But Richmond believes that all these problems are beatable, because "once you get a technological problem defined, you can beat it. We haven't given much thought to a research agenda, but one thing research could do is look more into the benefits of a more decentralized system."

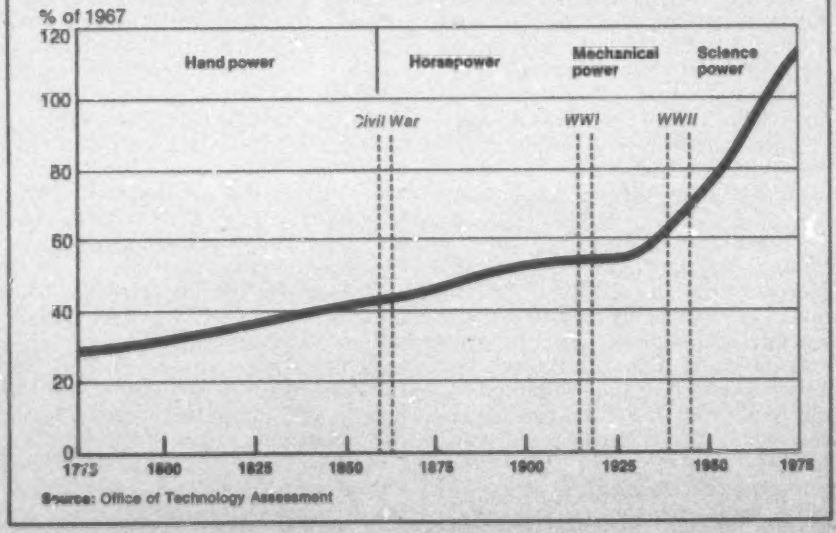
Many changes are happening simultaneously, and it will be the challenge of the experiment stations, agricultural laboratories, and extension services to serve these changes. Like in other segments of society, a historical transition is occurring through the evolution of both technology and a reviving sense of the importance of a land ethic.

Needed first is that bureaucratic fixing, a job that will fall to USDA's new assistant secretary for science and education, Orville Bentley, a biochemical nutritionist and former dean of the University of Illinois agricultural school. Bentley knows he has a big job ahead of him as the official who presides over ARS, CSRS, and the Extension Service. Shifting those elements into a single flowing stream won't be an easy task with a system whose focus is local and ferociously political.

Harwood: dislocation over next decade

"I wouldn't call what lies ahead a shakeup," he says. "But there is a change taking place that is more rapid than gradual. There will be a swing toward mobilizing our resources toward biotechnology, genetic manipulation. Two other important areas are resource utilization and protection of soil and water. I still think the driving force will be efforts to increase yields, productivity, and production as a way to keep the level of technology high."

Farm productivity shot up because of scientific revolution



Source: Office of Technology Assessment

Dennis Prager: rustler at the gates of land grant research

Dennis Prager knew he would be setting off a major political controversy when he and the Rockefeller Institute's John Pino organized the Winrock Conference last summer. To the experiment station directors in most of the land grant universities, Prager is evil incarnate, a no-good varmint, but not by any means to all such figures. The experiment stations at such land grant, research-intensive universities as Cornell, Wisconsin, Illinois, Michigan State, California (Davis), and Purdue have nothing to fear from this latest assault on the system. Their faculties already are competitive with scientists at non-land grant schools and are in fact urging Prager on. Moreover, the American Association of State and Land Grant Universities is giving its support to the Winrock findings.

It is the directors of the stations at the less renowned land grant schools that are after Prager's neck, and a campaign is on through Congress to blunt Prager's zeal if not remove him from his job. But with the protection of the White House, Prager seems safe.

Prager, a physicist, started work as a policy analyst at the Office of Science & Technology Policy during the Carter Administration. During that time he volunteered to take on the issues of agricultural research when a movement that turned out to be unsuccessful was launched in Congress to eliminate USDA's tiny competitive research grants program. "I found the agricultural research community to be complicated, factioned, and not like any other research group," he says. "Even if you knew a lot about NIH and NSF, you still wouldn't know anything about the ways

C&EN staff photos

of agricultural research. So I immersed myself in all aspects of agriculture and found myself giving talks all over the country to willing audiences."

But over time, Prager says, he came to be concerned with the quality of research at most of the land grant experiment stations and the degree to which the system was taking advantage of the tremendous amount of research going on outside agriculture. He says he wondered about the isolation of that system and found that a lot of people he respected shared this view. These were the people that were invited to Winrock.

"I began to feel there were problems that needed to be addressed, and then began running into tremendous hostility from the land grant community, especially in the Midwest," he says.

The speechmaking over, Prager and Pino then organized the conference. The report has been sent to Congress, and hearings are expected before the House Science & Technology Committee.

What is certain to happen are efforts to spread Hatch Act funds more widely through the research system. Whether it will succeed, however, is highly doubtful in the face of a land grant community loaded for bear. Prager says he is surprised at the ferocity of the response from the land grant opposition.

"They are well organized, conservative, and paranoid," he says. "Once they understand where the momentum is going, they try to spot the people behind it and rub them out. They are saying I'm trying to destroy the agricultural research system. They feel that the system is over 100 years old, it's productive, and doesn't need change."

Prager says he isn't out to kill the experiment station system. He says he doubts whether much ARS research needs to be done at sites where experiment station research goes on. But he thinks, as the Winrock report says, that ARS should be taking the longer-term, national view of agricultural problems. Much of the experiment station agenda is wholly legitimate, he says, and only a fool would want to scrap it.

"What I do know is that we have the most productive farmers in the world," he says, "and they are going to bust hand over fist. The bottom line is that if you draw a fence around ARS and the experiment stations, they are not producing enough basic knowledge to sustain productivity of American agriculture."

But the U.S. must address these harder issues, he says, "like the condition of the soil, the problem of rural America, the importance of agriculture for [the U.S.] balance of payments. [The U.S.] built an agriculture based on abundant natural resources. Now [it has] to find solutions for the benefit of society as a whole.

"I remember as a boy on the family's North Dakota farm the dust storms of the 1930s. Mile after mile of the soil was being plowed up, and we saw the consequences. Once you've been in a dust storm you never forget it. There should be a national goal to return fertility to the soil. And [U.S. farmers are] going to have to use organic fertilizers because the volume of chemicals needed is too great."

What Bentley sees is more federal involvement in changing the course of agriculture toward more conservation again. That will mean diversion of funds at a time when the Reagan Administration could be facing a budget deficit as high as $200 million for fiscal 1983. Otherwise, he says, he sees farms becoming larger and larger as farmers can no longer keep up their production to make enough of a profit.

Refocusing his agencies will be quite a job, he admits. And it will take a while. A year from now, his outside advisory group, the Council for Agricultural Science & Technology, will submit its report on what the Science & Education Administration should be doing to meet the challenges ahead. The chairman of the Council currently is Emery N. Castle, director of Resources for the Future, a Washington, D.C.-based research group. Castle himself made one of those assessments of agricultural research that appeared over the past two years. But Bentley already knows what the problems are, and there may be no time to wait for yet another report on U.S. agricultural research needs. ARS is already reorganizing for a longer range assessment and national policy role.

"It is going to be difficult to set goals with regard to specific scientific development, because so many different things are going on in agriculture all over the country," says Bentley. What he means is that agriculture is fundamentally local, and so any attempt to turn the experiment stations around toward a better blending with national goals

John Dunbar: a Kansas State hoosier takes on elite science

Anyone talking about amber waves of grain has to have the state of Kansas in mind. As much as any state and certainly more than most, the story of Kansas agriculture is one of an increase-and-multiply fusion of farmers, land, and technology. In these late autumn days, Kansas is green, laid over with a lush carpet of winter wheat, which will be harvested next summer. Once prairie, Kansas is now prime agricultural land, blessedly fertile and well watered in the eastern part, dry and once-sparing in the west. But western Kansas wasn't long left to its natural ecology. For under it lay the Ogallala aquifer, an enormous underground sea of ancient water that for the past 30 years has been pumped for the irrigation of a most unlikely crop: water-guzzling corn, grown to feed cattle all over the world.

There's a fierce pride that shows through John Dunbar when he talks about the Kansas State University Experiment Station. Dunbar is its acting head and is dean of agriculture at the land grant university. Currently he's not reacting any too happily to the Winrock Report's attack on experiment station research. He thinks it is born of snootiness, ignorance, and avarice.

On top of all that, Dunbar loves farming. On his farm in his native state of Indiana, Dunbar raises soybeans, corn, and popcorn. He believes any large-scale use of organic farming is romantic idealism, and he freely acknowledges that his experiment station exists for the industrial model of agriculture. Indeed, agribusiness is far from a dirty word in Kansas. Without agribusiness—the complex system that supplies seed varieties, fertilizer, machinery, irrigation systems, and agricultural chemicals to farmers—Kansas agriculture would have gone bust a long time ago.

But in this age of agricultural exports and balance of payments problems, he thinks that agriculture on an enormous scale and intensity is the path to the future. It's expensive agriculture with no room for the little man. Say what you will about intensive agriculture depleting the soil, ruining and wasting water supplies, and raising tolerance to pests, Dunbar believes that research will solve any problems that come along. Farmers, in fact, do use organic forage techniques to supplement their chemical fertilizer input, he says. Even when energy costs get too high to pump water in western Kansas, research will help the farmer return to dry-land farming. Only this time such agriculture will not succumb to the

climate's vicissitudes, which the sod-house homesteaders had to endure during the late 19th century. This time, fancy and fanciful seed varieties, conservation practices, fertilizers, and farm chemicals will ensure a productive new era. Water-intensive farming is fading from western Kansas and Dunbar knows it. But it's no reason for panic, he believes.

So in Kansas, confidence in agricultural research looms eternal, if only the elitist research reformers would keep off the backs of the states. In the past, cattle rustlers used to invade ranches and make off with prime livestock. This time the rustlers are making a raid on experiment station research funding and Dunbar is fixing to put up a strong fight.

"No one knows what they're talking about when they say we don't do basic research here," Dunbar says. "Nor do the same people know anything when they say we don't do peer review at places like this." Dunbar's "places like this" hardly fits the experiment station stereotype: a Victorian structure staffed by aging researchers at the fringe of the campus. At KSU, the station is in reality a system of funding research and setting its priorities among 32 departments competing for those Hatch formula funds. There are, however, five branch stations around the state, each dealing with the farm problems in its particular area.

Nor is the picture of a single titular head dispensing Hatch Act funds on eccentric whim anywhere near the truth. Hatch funds are distributed by in-house review committees. Those who are producing good research get funded. Those who aren't competing in their fields get left out. Many of the younger faculty members are earning more money than some of the older staff.

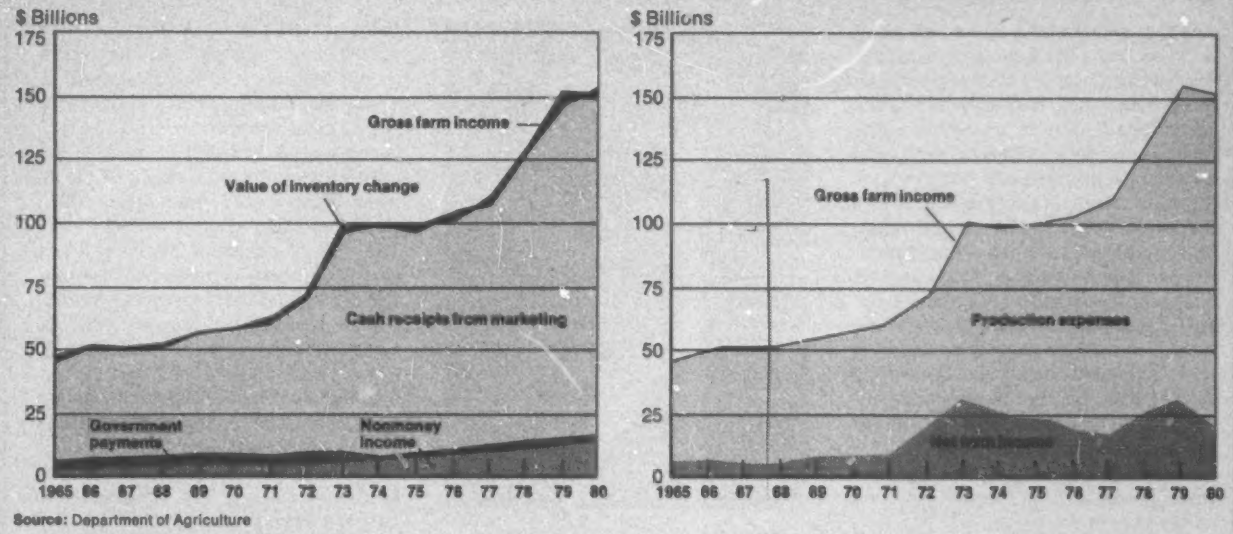
Kansas soil, especially in the more rainy eastern section, is eroding much faster than it is being formed. In the western part, the Ogallala aquifer is indeed being mined much faster than Rocky Mountain runoff is replenishing it. The energy costs for pumping it are straining farmers' budgets, and many are leaving agriculture. Mostly the already rich are surviving and growing. Although Kansas law prevents the purchase of farms by big corporations, nothing forbids families like the Gigots of western Kansas from becoming conglomerates in their own right. The Gigot success story—they started with only a few acres and little money—is in fact the farmer's epic dream.

A gap stretches between Dunbar's industrial paradigm and that of places like the Land Institute in Salina or the Kansas Rural Center in Whiting. At the Land Institute, a few well-educated mavericks led by Wes Jackson are teaching and practicing an agriculture aimed at restoring diversity to Kansas agriculture. Research is being done, for example, on perennial grains that are more native to Kansas soil. At the same time, they are trying to preserve a romantic sense of farmers and land that they believe is being lost under the industrial model.

Jackson thinks that big companies, like the combination of Pepsico and Prudential, that have operations in Kansas are showing scant concern for soil conservation. And he is especially critical of Ogallala irrigation practices in western Kansas. "What [these big companies] are doing," he says, "is using that water to create a desert. I really blame the land grant institutions for what's happening. They exercise very little leadership. They discovered the parade and they got ahead of it. Dunbar is transient. But the forces that put him there aren't. I'm happy to do battle with them. I look at the farm as a hearth; they look at it as a factory."

But Dunbar says farmers have no time or inclination to go back to a style of agriculture that will lower yields or reduce income for a year or two. They already owe too much to the banks from loans on expensive farm equipment and land purchases. Whether there will be a showdown of values in Kansas, however, is doubtful. The existing system will go its way; the Land Institute believes its values eventually will work their way to the top.

Farm income comes mostly from marketing and goes mostly to pay production expenses



Source: Department of Agriculture

could be wishful thinking. The experiment stations already are proud enough of what they do. In fact, the stations say that what they do is often better and more relevant than what ARS does. Also, they will fight any attempt by the non-land grant institutions to make off with Hatch Act money. Kansas State University dean of agriculture John Dunbar says his budget is already worse than tight. He says his science departments have 32 research and teaching vacancies to fill as it is.

But what Bentley says will be done are investigations into diverting some of the farm subsidy money, $7 billion or so, toward research and conservation. That will involve a fight. Also, there's considerable sentiment toward siphoning off to the reconstituted, refurbished ARS and the USDA's competitive grants program some of the agricultural research funding NIH and NSF distributes to scientists at non-land grant schools. What Bentley will get is plenty of outside advice. His units already are the target of plenty of criticism.

"There is no question," says one plant researcher outside the land grant system, "that USDA is a fat bureaucracy. The regional laboratories represent a lot of the worst research, but although good science is still going on there, there's not a lot of it. We have to encourage the good ones to keep doing good research and weed out through retirement the others.

"People like Prager would like to scrap the whole system and build a new one; it's cleaner doing it that way," he continues. "But we don't know enough about what makes bureaucracies encourage mediocrity. So there's no assurance that putting a lot of young people in the system wouldn't create in 10 or 15 years the very same problems we're complaining about today."

William E. Marshall, a biochemist who is technical director in the development sector for General Foods Corp., has been studying federally funded agricultural research in his assignment as a member of President Reagan's Task Force on Cost Control. As he sees it, USDA as yet has no long-term goals that it is moving toward.

"What is clear from my studies," he says, "is that the state agricultural experiment stations are in danger of losing their pre-eminent role in agricultural research. There are two reasons for this. As agribusiness grew, the research system became mature and as a result needed a lot of maintenance work. That was time and money taken away from research. [The stations] had to keep track of new pests, evaluate new fertilizers, and the like. That prevented growth of real research. Second, it was becoming evident that the future of agricultural advances lay in developments in plant biology, and the best work was being done outside the system. Animal science is the same story. My feeling is that we don't have yields up as high as we could in livestock. We're now importing some strains of pigs from China, for example, because their litters are greater."

Marshall is unsure whether USDA will be able to adapt to gain preeminence in research. "I don't feel that it has the level of fundamental science under its control or within its sphere," he says. "What's needed is to bridge the gap between molecular biology and the future of agriculture. The system isn't really running at top capacity. There's a lot more it can produce."

Hugh Murphy, professor of agronomy at the University of Maine, speaks with Yankee practicality in his comments on the Winrock spate. "I saw some of that report," he says, "and it looks fine but it didn't get down to the nitty-gritty of things. The farmer wasn't really spoken for in the report, and although I can agree with the fascination of molecular genetics and biotechnology, most of the research there won't find practicality for 10 or 15 years. Even developing new breeds and strains takes 15 years by the regular plant breeding way before they're ready for the field. Besides, you're talking about new farming practices when you develop a new strain." And speaking for potato research, his specialty, Murphy believes that much more knowledge already lies on the shelf than can be used.

But where Murphy turns away from his conservatism is in his criticism of ARS research. "ARS got started for the purpose of doing research of the basic type that experiment stations were not able to do. The trouble is that when Congress came to appropriate money, it would ask what ARS had accomplished and so it got into more applied areas. So now ARS is doing a lot of the

same research the experiment stations are doing. I contend that when you have two units doing the same research, one of them is wasting money. Then, when I ask who should be doing that research, I also ask who is closer to the grass roots."

ARS director Terry B. Kinney is aware of all the criticisms and says that in the big review of his agency now taking place, 5 to 10% of ARS's 148 laboratories will be closed or sold off. "There are powerful changes ahead," he says, "and as we look at our strategic plan and the redirection of our programs we'll have to carry out our redirection rapidly. We will have to tell scientists that they will have to move and start new careers in new fields of research. At the same time, we're taking a hard look at administrative costs. Currently 14% of our budget goes into those costs. We want to cut that figure to 12%. That may not sound like much, but it means releasing several million dollars more for research."

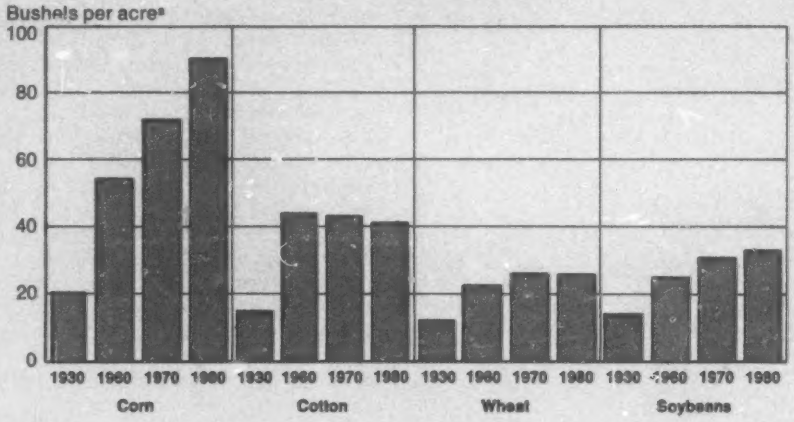
Kinney believes ARS research is much better than the public's image of it, pointing out, for example, that the new bovine vaccine for hoof-and-mouth disease developed through genetic engineering was a product of ARS's Plum Island, N.Y., facility. He says many ARS laboratories have top research groups, and he plans to underscore the work of these centers of excellence. The best places will get increased funding and researchers.

He also thinks USDA's competitive grants program, now funded at only $16 million, should rise to "at least $100 million." He says he isn't interested in having management of that program transferred to ARS, a move that would make ARS parallel in function with NIH. But he does think there could be better coordination of the external funding of agricultural research with the large overview ARS has of research priorities. He is piqued, however, at the new attention agricultural research is getting from the general research community.

What is certain about the agricultural research system is that it isn't very tolerant of glib solutions. It's complex and as such doesn't really exist as one system. There is the system of individual pest control for individual crops. There is a system for producing new seed strains to enable, say, the growing of soybeans in the northern plains states. There is a system for the purchase of instrumentation for agricultural field-station laboratories, and obviously each crop is a system in it own right. In short, each agricultural specialty has its system, or information network.

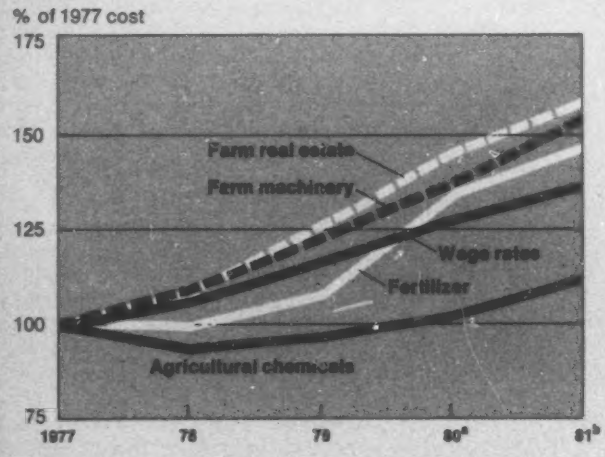
Where this system is being systematized, as it were, is in the agricultural extension services at the county agent level where relevant information from the laboratories must be brought to the needs of the farmers. Here, computerization is coming on fast and this development alone is what could change the shape of U.S. agriculture in the needed biological and land policy directions. That is, it may force the formation of a "metasystem," some combination of conservation values, even in their more romantic aspects,

Only corn yields have continued up sharply

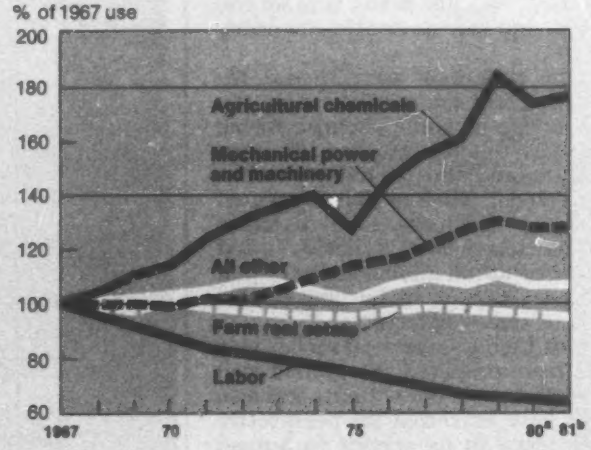


a Pounds per acre x 10 for cotton. Source: Department of Agriculture

Fastest-rising farm cost in recent years is land...



...whereas chemicals are fastest-rising production factor



a Preliminary. b Estimated. Source: Department of Agriculture

C&EN staff photo

Terry Kinney: aware of criticisms

which will preserve the kinds of values the Richard Harwoods and Wes Jacksons want to see protected.

One problem seems to be that of accountability for decisions. The administration of research appears to be scattered throughout the USDA bureaucracy. "No one knows who is accountable for developing research priorities around various crop and animal research," declares Joseph Kinney, staff director of the committee on agriculture of the National Governors' Conference.

Kinney says the governors will be paying a lot more attention to agricultural research problems over coming months in efforts to improve state-sponsored agricultural research. If the federal government fails to cut back military research, and if agricultural research needs are so great, then states are going to have to pick up the slack. "And the situation looks bleak," according to Kinney. "We just aren't sure we can make up the domestic spending cuts."

One aspect of agricultural research's problem may be a scientific self-image. Organic chemist Liebig was the founder of chemical agriculture, and thus of today's industrial model, when in 1840 his paper, "Organic Chemistry in Its Relation to Agriculture and Physiology" stood the agricultural establishment of that time on its head by burying the old humus theory of fertility.

But Liebig's chemical model may not have prepared the system well enough for the era of limits and also may have narrowed the perspective of science in its service to human and agrarian values.

Stan J. Dundon of the University of Delaware's Center for the Study of Values, thinks so. To gain acceptance among peers, scientists must pursue research, and publish on highly specialized topics. Agricultural scientists, many isolated in laboratories and divorced from the farm, are under the same influence. They seek reputations among their fellow disciplinarians, not necessarily among farmers, and certainly not the "muck and mystery" pursuits organic agriculture represents to them, even if it might represent a cheap cure to some big problems. Liebig's descendants likewise can't be expected to leave their molecular pursuits to measure the impact of native species of legumes on soil fertility.

And, says Dundon, even if today's scientists recognize the benefit of developing nitrogen-fixing qualities to nonleguminous plants, the brightest and most ambitious among them will choose recombinant DNA research as the approach. They are unwilling to squander their careers by drably searching out nonconventional native species of plants that might be bred as natural sources of nitrogen. This is what the Land Institute is doing.

"This DNA research," Dundon points out, "is typical U.S.-based laboratory, home campus research. Highly specialized articles are published in disciplinary journals, leading to promotion in publish-or-perish disciplinary departments, and remunerative relationships are established with appreciative clientele."

A composite picture of the germ plasm collector, on the other hand, he says, "is that he or she is funded by the Mennonites, out slogging in the jungle or on mountainsides, finding promising new species or adapting them from native farmers and running tests on them, studying the social and economic factors needed to integrate the innovations into village farming systems, writing in interdisciplinary journals, and ending up as curators of botanical museums."

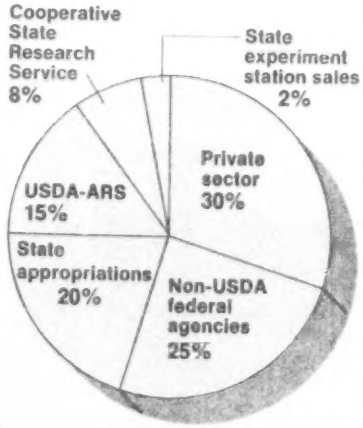
Bentley: create one national system

But it isn't only establishment research in agriculture that may have the problem. Its critics from basic science may themselves need another form of agrarian sense. Vernon J. Ruttan, University of Minnesota agricultural economist and author of the just-published book "Agricultural Research Policy," thinks so. "It is time," he says, " for the general science community to begin to follow the lead of the agricultural science community in embracing the fusion of science and technology rather than continuing to hide behind the indefensible intellectual and class barriers that have been retained to protect its privilege and its ego from contamination by engineering, agronomy, medicine, and the social sciences.

"This change will become increasingly important in the future as the close of the fossil fuel frontier joins with the close of the land frontier to drive technical change along a path that entails the emergence of a much larger role for biological and information technology."

On that thought, the Wes Jacksons and the John Dunbars can grip the same till, or carve at the same turkey. □

Government big supporter of agricultural research



Total funding = $2.5 billion, fiscal 1981

Source: White House task force

Petrochemicals inch toward recovery

Following a low in output this summer, basic olefins and aromatics are starting the long road back to financial health

Bruce F. Greek
C&EN, Houston

U.S. petrochemicals have been knocked flat financially and generally are operating in the red. It is long past time for the recovery once hoped for in the second half of 1982. Some industry people are now pinning their hopes on the second half of 1983, but others aren't looking for full recovery until 1984 or respectable profitability until 1985.

Currently, production rates of the five major petrochemicals treated in the following pages—ethylene, propylene, butadiene, benzene, and *p*-xylene—have inched up from the summer trough. But output at a combined 51.8 billion lb for 1982 remains fully 20% below 1979 peak levels and in some cases is still below levels of a year ago, when the production slump was in full swing.

A production upturn in 1983 might not exceed 10% and could be as low as 5%. That would leave combined volume of the five well below 1981's 60.0 billion lb, to say nothing of 1979. In fact, it would take a further 10% pickup in 1984 for output to exceed 1979 levels. Even then butadiene and benzene might not make it back, given their sluggish growth forecasts.

If petrochemicals' volume picture is bad enough, the value side is even worse. Severe pressure on prices has hammered down combined production value of these five petrochemicals by an estimated $3.5 billion, or nearly 25%, in 1982 from about $14.5 billion in 1981. A 10% volume rebound in 1983 might add only $1 billion to sales. Another 10% volume gain in 1984 with stronger prices might bring dollar sales back to the 1981 level.

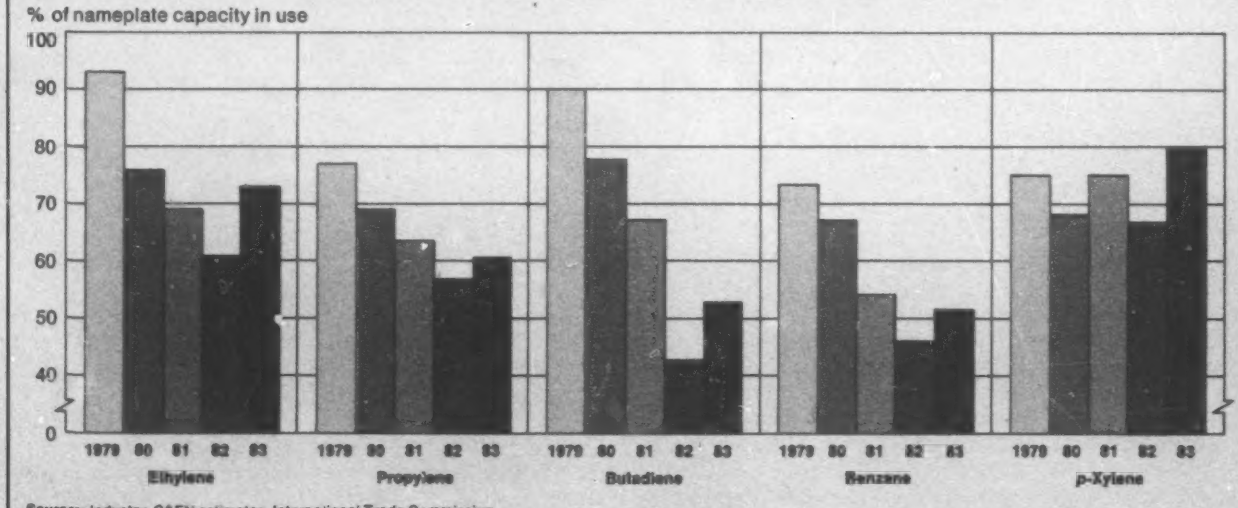
But even this slow improvement is considered optimistic by many analysts in the industry. Top managements have become similarly cool, overriding proposals for any kind of plant expansion except for certain specialty grades. New investment is being pruned continuously, and current plant spending is going largely to complete projects begun one to three years ago.

Operating costs also are being pared where possible, although the big savings here, from feedstock switching, already have been made. Since little new-plant investment is due until late in the 1980s, this feedstock cost factor will be the big one facing producers. This year, as in the past several, a shift has continued toward the lightest possible feedstocks for steam crackers even at the loss of coproducts. These light hydrocarbon raw materials—ethane, propane, and to a lesser extent butane—are still cheaper than heavier gas oils or naphtha despite a large price increase this year.

Later in the decade, the light hydrocarbons' cost advantage could fade, according to some industry analysts. By this view, lower demand for natural gas will reduce new gas discoveries and, with them, the availability of new ethane and propane. In addition, natural gas will continue to be drier (contain less separable ethane and propane liquids). Gas prices would increase, pulling light hydrocarbon prices along with them.

The current consensus is that from now until 1985, ethane, propane, and butane will be used as much as possible even with rising gas prices. As a result, more propylene, benzene, and *p*-xylene than usual will come from refinery streams, and butadiene imports from Western Europe could continue to rise. □

Plant-use rates finally may turn up if gradual recovery starts in 1983



Sources: Industry, C&EN estimates, International Trade Commission

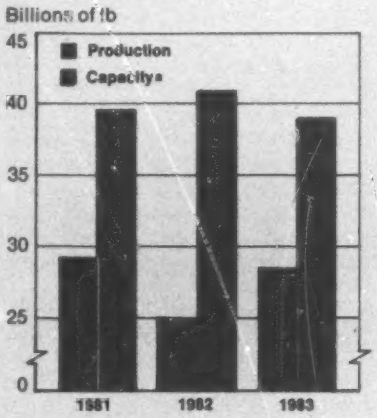
Key Chemicals

Ethylene

$CH_2{=}CH_2$

- ***Demand in trough***
- ***Capacity chopped***
- ***Prices reviving***

PRODUCTION/CAPACITY



a First quarter.

HOW MADE

Thermal (steam) and catalytic cracking of hydrocarbons ranging from natural-gas-derived ethane to oil-derived gas oil (fuel oil)

MAJOR DERIVATIVES (U.S.)

Polyethylene 45%, ethylene oxide 15%, vinyl chloride 15%, styrene 10%

MAJOR END USES (U.S.)

Fabricated plastics 65%, antifreeze 10%, fibers 5%, solvents 5%

FOREIGN TRADE

Negligible

PRICES

List prices mainly 21.5 cents per lb

COMMERCIAL VALUE

$5.0 billion for production, 1982

With U.S. production far exceeding output of other major olefins combined, ethylene is a good proxy for the whole sick petrochemical industry. Petrochemicals have been sandbagged financially, and ethylene, sure enough, is one of the more exaggerated cases.

Currently, ethylene seems to be at the end of a year-long shakeout. Sagging demand has led to production and capacity cutbacks. After all this, 1982 output probably will total only 25 billion lb, possibly a bit less—down 15% from 1981. Since actual demand this year for ethylene could reach 27 billion lb or so, inventories have been slashed nearly 2 billion lb.

Whether the inventory reduction is over will be important to ethylene's prospects in any economic pickup in 1983. Industry analysts present several cases. At worst, ethylene demand would be almost stagnant in 1983 with continued downward pressure on prices and output. This would call for a further tug on inventories. More optimistically, demand would pick up, especially in the second half of 1983. That would induce inventory building and raise production over demand for the year. Presumably, the second case would mean stronger prices, making a larger inventory more affordable.

Prices can have such levered effects in a year like this one, when they have changed almost unimaginably fast. Prices plummeted last winter, from a real market level of 25 cents a lb to below 17 cents by spring. Then in the summer as feedstock prices rose, especially spot prices of ethane and propane, ethylene list prices went back up to the low 20s per lb. Discounting now holds real prices close to 20 cents.

That means ethylene prices have not risen as fast as have skyrocketing prices for the dominant light hydrocarbon feedstocks. Ethane has about doubled to 28 cents a gal and propane is up nearly as much proportionately to 50 to 55 cents a gal. About the only feedstocks down in value are the less desirable refinery raffinates left after aromatics are removed from the product streams of catalytic reformers. These raffinates may continue to be low valued, seeking an alternative market to slumping use in gasoline.

Relatively low ethylene prices hurt overall company profitability in two ways. Little net income comes from ethylene itself. In addition, low prices for ethylene cause buyers of the same companies' ethylene derivatives to expect low prices for them as well, severely limiting returns in downstream processing.

With low profitability come low plant operating rates, plant shutdowns, and scrappage of some capacity. At this time, at least 5 billion lb per year of annual nameplate capacity is still shut down "temporarily."

But some capacity is gone forever. During the past year, about 2 billion lb per year of ethylene capacity has been closed permanently. These include small units that processed refineries' off-gas streams as well as older steam crackers.

Since most of the ethylene units taken down in 1982 hadn't run for some time, average nameplate capacity for the year was unaffected. At 39.5 billion lb, this capacity had an average operating rate of 63%, a bit higher than the average estimated for mid-year (C&EN, Oct. 11, page 12).

In 1983, the operating rate for ethylene plants likely will rise substantially. Production could be up nearly 15% to 28.5 billion lb, the midpoint of an opinion range from industry sources—even with some inventory cutting to meet demand. Therefore, the 1983 operating rate might easily be 10 percentage points higher. If more scrappage occurs, the use rate could easily reach 75% of nameplate capacity.

Such production depends on a substantial upturn in demand for currently weak derivatives such as vinyl chloride and a lesser, but still strong, upturn for less depressed derivatives such as polyethylene. Most ethylene derivatives will not make it back to 1981 levels in their 1983 use of ethylene, but they should be getting close.

Such a recovery will return the use pattern of ethylene to normal after small changes in 1982 as polyethylene gained at the expense of vinyl chloride. What will not return to past patterns will be ethylene's production growth rate, now permanently lower. After pushing up an average of 6% per year from 1969 through 1979, ethylene now will be lucky to go at half that pace in the 1980s.

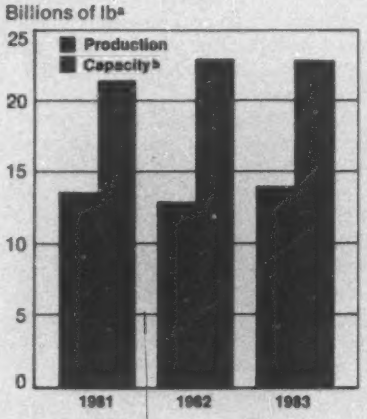
Key Chemicals

Propylene

$CH_2{=}CH{-}CH_3$

- ***Production off a bit***
- ***Capacity flat***
- ***Prices down***

PRODUCTION/CAPACITY



a Chemical and polymer grades. b First quarter.

HOW MADE

Recovered from cracked gas streams made in olefins plants and oil refineries

MAJOR DERIVATIVES (U.S.)

Polypropylene 25%, acrylonitrile 20%, cumene 10%, 2-propanol 10%, propylene oxide 10%

MAJOR END USES (U.S.)

Fabricated plastics 50%, fibers 15%

FOREIGN TRADE

Exports—negligible, imports—holding at about 500 million lb in 1982

PRICES

Chemical grade 19.5 cents a lb, polymer grade 21 cents a lb

COMMERCIAL VALUE

$2.75 billion for production, 1982

Propylene has an image problem. It has to exist in the shadow of ethylene and gasoline in spite of a large increase in both its use and relative value over the past decade. It is still classified as a coproduct—ethylene's in the case of olefins plants' steam cracking or gasoline's in the case of refineries' catalytic cracking. Seldom is it made on its own.

As a coproduct, propylene plays an economic support role. It can help steam cracking, for instance, by contributing scarcity value when ethylene demand and prices are low. But it hinders refining economics through the additional processing costs needed to make it into a useful component of gasoline.

In all sources, to get something from propylene, purification is needed. So both kinds of producers have to add propylene splitters. For this equipment, economics work best if capacity is large enough to handle all available propylene for some time to come.

Such economic considerations help explain the large excess plant capacity and low use rates in U.S. propylene. If 1982 propylene production falls only 4% from 1981 to about 13 billion lb, available capacity will run at a lowly 55% of nameplate capacity of 23 billion lb per year. Next year, capacity utilization probably will be up a bit, to perhaps 61%, if production goes over 14 billion lb and capacity holds.

Capacity for propylene is hard to pin down. Designers can always push up capacity of the distillation towers for purifying propylene simply by adding to diameter. Such excess capacity can be useful when a producer with a ready market finds a chance to purchase a cheap hydrocarbon stream containing propylene. The tricky part is that the tower's capacity for propylene depends on factors such as concentration of propylene in the feed and purity of product needed—chemical or (higher) polymer grade. Depending on these factors, capacity is either over- or understated. Industry sources estimate that the actual total capacity range could be from 20 billion lb to 26 billion lb per year.

Because propylene units are relatively easy and inexpensive to shut down and restart, they have to be counted as operable even though long out of action. Currently, there is a lot of such capacity in refineries that likely will never run again.

If at some point ethylene demand picks up at the other propylene source—olefins plants—and feedstock needs exceed supply of light hydrocarbons, more gas oil (now shunned because of high cost) will be used to make ethylene. Coproduct propylene of necessity will be larger. Since steam-cracker propylene must be either sold or burned as fuel, it will not only tend to force a market but also control the propylene price at all sources, including refineries. With such a potential competing supply bulge over their heads, refiners may not restart their propylene towers even if both gasoline and ethylene demand surge when the economy recovers.

For the near term, however, more propylene than usual will come from refineries. One reason is the low propylene yield from steam crackers, which still favor ethane and propane feedstocks. The second reason is the current high cost of isobutane, which refiners react with propylene to produce an alkylate to blend in leaded gasoline. Given the high price of isobutane, refiners' interest in alkylation has sagged, and they are pushing surplus propylene into chemicals.

This movement of refinery propylene into chemical and polymer uses pushed propylene prices down during the third quarter. The propylene price is now about equal to ethylene's after sporting an unprecedented premium earlier this year. Analysts feel, however, that the propylene price is unlikely to resume its old level of 70 to 80% of the ethylene price.

The largest use of propylene, polypropylene, has been hit hard by declines in two of its major end-use markets, housing and automobiles. Polypropylene production through August fell 17% from 1981. Sales declined less, indicating a slash in inventories, according to the Society of the Plastics Industry's Committee on Resin Statistics.

Because of low overall expectations for early 1983, prospects for full-year propylene production are for a modest increase of 7 to 8%, with most of that coming in the second half.

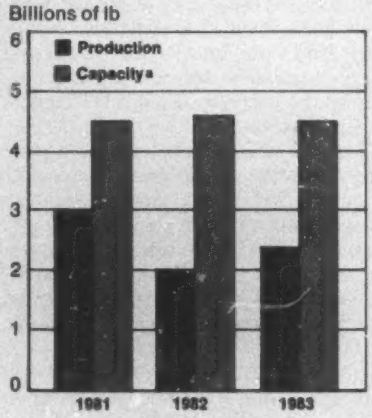
Key Chemicals

Butadiene

$CH_2{=}CH{-}CH{=}CH_2$

- ***Production way down***
- ***Capacity declining***
- ***Prices torpedoed***

PRODUCTION/CAPACITY



a First quarter; includes all extraction capacity.

HOW MADE

Recovered from steam-cracker product streams; dehydrogenation of butylenes from oil refineries

MAJOR DERIVATIVES (U.S.)

Styrene-butadiene rubber 40%, polybutadiene rubber 20%, hexamethylenediamene 10%

MAJOR END USES (U.S.)

Rubber products 70%, fibers 10%

FOREIGN TRADE

Exports—holding at about 70 million lb in 1982, imports—rising to more than 700 million lb

PRICES

List price 31 cents a lb

COMMERCIAL VALUE

$600 million for production, 1982

In the odd world of butadiene, at least one thing is pretty clear. Its market essentially means rubber, and rubber, in turn, means transportation as the main end use. In this recession year, transportation—in terms of auto manufacture and tire use—has slowed to a crawl. Although demand for butadiene held up remarkably well through 1981, it fell hard this year, and recovery will be painfully slow.

The transportation setbacks in 1982, including an auto production rate barely half that of peak years, have crippled butadiene. It has suffered more than most other big-volume petrochemicals. Production in 1982 will do well to exceed 2 billion lb, off by one third from 1981 production. Many plants, including all independent dehydrogenation units, currently are shut down. They will not be restarted before late next year, if at all.

Some of the dehydro capacity is down for keeps. For example, Copolymer Rubber & Chemical's Baton Rouge, La., plant is closed permanently and will be removed. Some by-product butadiene capacity also is largely out of the picture, the result of 2 billion lb per year of ethylene capacity being permanently closed in 1982. In the case of steam crackers in these shutdowns, the extraction capacity for removing and purifying butadiene has not generally been scrapped and is kept available for intermittent use.

Because so much extraction capacity for butadiene waits in the wings, still counted as operational, the overall plant use rate for butadiene has fallen to an unusually low level, 43% for 1982. A slight recovery may occur by the end of the year as ethylene operations improve and inventories of butadiene approach record low levels.

Despite the low official operating rate, steam-cracker operators are still processing all the butadiene the crackers can turn out. The trouble is, basic butadiene output from steam crackers is down because of the shift to ethane and propane feedstocks. Such feedstocks produce very little coproduct butadiene compared to heavy-liquids feedstocks such as naphtha and gas oil. Barring another price explosion in ethane and propane, the lightest feedstocks will continue to give the lowest-cost ethylene. A slight shift away from ethane and propane may be in the cards for part of 1983, but the change probably will not be large enough to add very much butadiene output.

Possible reopening of the independent butadiene plants in 1983 will depend on several economic influences. Fuel cost, mainly for natural gas, is important as is cost of raw-material butylenes. As with so many other petrochemicals, butylene costs are influenced strongly by their alternative value as a material for gasoline. Behind the scenes, then, gasoline vagaries, such as the ratio of leaded to unleaded production (which helps determine butylenes use) can weigh heavily in butadiene producers' decisions to operate the dehydro units.

An even more important part of decisions on dehydro plants will be the selling price of butadiene. Butadiene prices have tumbled this year, from about 40 cents a lb to about 30 cents. At current price levels, industry sources are unanimous that operation of dehydro plants is out of the question.

Part of the reason for the slump in butadiene prices has been a rise in imports. Coming mainly from Western Europe, imports will top 700 million lb, possibly more than 750 million lb in 1982, way up from 1981. At these levels, imports will account for more than one fourth of U.S. demand, compared to less than 20% in 1981.

Imports are up because Western European ethylene plants continue to use largely naphtha or heavier feedstocks, which give large quantities of coproduct butadiene. (There are no operating dehydro butadiene plants in Western Europe.)

Since European economies are doing so poorly, butadiene is in unusually large surplus, and the only options are exporting or burning. Forced exports to the U.S. and elsewhere, if unprofitable, at least bring some income. Until business in Europe improves greatly, this butadiene export pressure will continue.

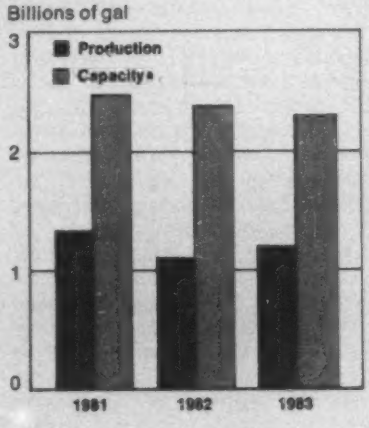
So in 1983, U.S. butadiene imports could match 1982 no matter what the U.S. economy does. And U.S. butadiene production will suffer accordingly. Chalk up a still-depressed 2.4 billion lb as the resulting outlook for butadiene output next year.

Key Chemicals

Benzene

- ***Demand off***
- ***Capacity down a bit***
- ***Prices flat***

PRODUCTION/CAPACITY



a First quarter; includes all sources.

HOW MADE

Separated from aromatics streams from oil refineries, steam-cracking olefins plants, and coking of coal; dealkylation of toluene

MAJOR DERIVATIVES (U.S.)

Ethylbenzene 50%, cumene 20%, cyclohexane 15%, aniline 5%

MAJOR END USES (U.S.)

Styrenic plastics 35%, phenolic polymers 20%, nylon 15%

FOREIGN TRADE

Exports—small, imports—more than 100 million gal in 1982

PRICES

List price $1.55 per gal

COMMERCIAL VALUE

$1.7 billion for production, 1982

Benzene beats out even butadiene for complexity among the basic petrochemicals. With four major types of supply sources, and half a dozen important uses, benzene producers and consumers have a lot of options, all massively influenced by the rise and fall of gross national product in expansions and recessions.

Benzene is produced by about three dozen companies. For many, their benzene business is minor in their total operations, sometimes a prom maker and sometimes a financial millstone. For example, petroleum refiners make benzene for gasoline and charge outsiders the basic cost of aromatics streams plus recovery and purification expenses for use in chemicals. Another supply group, chemical subsidiaries of oil companies, makes benzene when they steam-crack heavy feedstocks in olefins plants. The same subsidiaries sometimes dealkylate toluene to benzene. And other companies who coke coal make benzene as a by-product.

Some benzene producers also make derivatives, but a large number of derivatives makers buy benzene and then compete with benzene producers. Some of these nonbenzene producers make their entire business in benzene derivatives, but other companies couch these derivatives in a much bigger operation. To top it off, some benzene producers don't make enough to meet their own needs for derivatives, so they are also benzene buyers.

This complex makeup of the benzene community naturally makes exact data difficult. Production of benzene for 1982 is estimated at 1.1 billion gal but could range between 1.0 billion and 1.2 billion gal. Plant capacity has been falling during the year and will be about 2.3 billion gal as 1983 opens, down from 2.4 billion a year earlier. For 1982, the average plant operating rate will be only 45% of nameplate capacity.

But some benzene units, particularly dealkylation units, will have zero operating rates this year. Others, especially units extracting aromatics from refinery catalytic reformate and from pyrolysis gasoline made in steam-cracking olefins plants, will operate way above 45%. In addition, some coke oven operators, because of low related steel-making rates, have found that economics favor their selling light oil by-product containing benzene and not taking the added expense of operating their benzene separation units. So this benzene reaches the market even though the specific benzene units don't operate.

Dealkylation units, which could account for a quarter of U.S. benzene supply if economics favored their operation, are likely to remain down well into 1988, maybe the whole year. Toluene, separated from reformate and pyrolysis gasoline, has too high a value now to be dealkylated, since discounted benzene is only $1.50 a gal. Partly behind toluene's current value is a shift toward unleaded gasoline and increasing compression ratios in new car engines. These trends help to hold up toluene's value as an octane-boosting alternative to lead alkyls. Some counterpressure on toluene's octane-boosting value comes from competing octane boosters such as methyl *tert*-butyl ether.

A renewed rise in benzene's price will be slow in 1983. Demand will first have to pick up in derivatives. At the same time, derivatives' prices also will have to go up. But such increases don't seem likely soon, because the economy is giving little help to end uses such as packaging for polystyrene or adhesives for phenol derivatives.

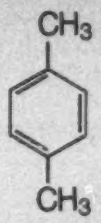
Styrene via ethylbenzene accounts for about half of benzene demand in the U.S. A small amount of ethylbenzene is recovered from mixed xylenes streams at oil refineries, but most is made by alkylation of benzene with ethylene. Dehydrogenation of ethylbenzene yields styrene. Styrene, in turn, goes into polystyrene, into polymers with acrylonitrile and butadiene, and into still other polymers. All of these polymers have been hit hard in the recession.

Of the other uses of benzene, cyclohexane, the product of simple hydrogenation, has been hit hardest. Since most cyclohexane goes into nylons, and the biggest nylon use is carpets, a recovery in consumer spending for housing and furnishings will be needed for cyclohexane's use of benzene to return to 1981 levels.

In short, a resurgence in benzene could begin in 1983, but it will take more than a year, possibly more than two years, for production to get back to 1979 levels.

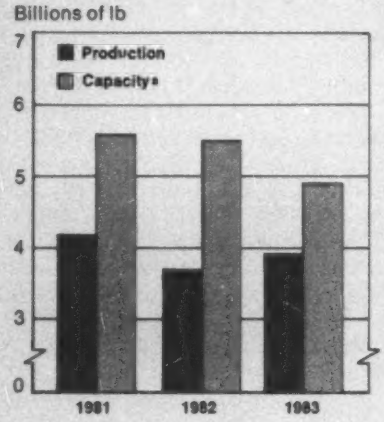
Key Chemicals

p-Xylene



- ***Output down***
- ***Capacity also down***
- ***Prices weak***

PRODUCTION/CAPACITY



a First quarter.

HOW MADE

Separated from mixed xylenes made in oil refineries or in steam-cracking olefins plants

MAJOR DERIVATIVES (U.S.)

Dimethyl terephthalate 55%, terephthalic acid 45%

MAJOR END USES (U.S.)

Polyester fiber, film, and fabricated items (mostly bottles) almost 100%

FOREIGN TRADE

Exports—down to 600 to 700 million lb in 1982, imports—may reach 50 million lb

PRICES

List price 26.5 cents per lb

COMMERCIAL VALUE

$950 million for production, 1982

After the complications of the benzene market, *p*-xylene offers a certain relief in simplicity. But relief is the last thing *p*-xylene producers feel about their hard-pressed business.

Of the five large-volume basic petrochemicals, *p*-xylene is the only one with essentially one use—polyester. Other outlets exist such as herbicides and solvents, but these probably take less than 0.5% of U.S. *p*-xylene production. Clearly, as polyester goes, so goes *p*-xylene.

Such market singularity wasn't always bad. The boom in polyester a decade ago provided heady growth rates for *p*-xylene. But as often happens, these rates attracted too many producers, leading to overcapacity and downward price pressure. The result in the past few years has been a shakeout. Capacity has declined, notably in Puerto Rico with the failure of Commonwealth Oil and its associated chemical companies.

Late 1982 U.S. nameplate capacity for *p*-xylene is 4.9 billion lb per year, down some 900 million lb from peak capacity a few years ago. Operating rates have held roughly flat in spite of a 12% decline in 1982 production to 3.7 billion lb from 1981. This year, the operating rate will be about 67% of nameplate capacity and about 75% of capacity actually in operation.

Forecasts of *p*-xylene production are risky because companies underreport production and then revise totals later, adding as much as 500 million lb to initial estimates of the U.S. International Trade Commission. For the first eight months of 1982, official *p*-xylene production is running at about a 3.2 billion to 3.3 billion lb annual rate, well below industry sources' final estimates for the year.

Even with its reasonably good plant operating rates, *p*-xylene has felt downward price pressure this year from slumping demand. Prices are down about 5 cents a lb from a year ago, or more than 15%. Part of the reason is a plentiful supply at refineries, the result of declining demand in the competing gasoline market. Of course, gasoline can always soak up the basic xylenes streams at refineries quickly if demand turns around.

p-Xylene's price decline also reflects a slumping export market, which takes nearly 20% of U.S. production. Major *p*-xylene buyers in Europe and Japan have cut purchases. The resulting export price tumble has contributed to price cuts for U.S. sales.

Next year's outlook for exports naturally depends on the state of foreign economies. At this time, industry sources look for little improvement in early 1983. Inventories are still high even with the drop in 1982 production. Downstream, polyester fiber inventories also are high relative to sales. About the only favorable inventory level among *p*-xylene's end uses is in bottle resins, which have an expanding market.

The fibers market has been chaotic in 1982. Everything has seemed to go wrong. Exports declined as China chopped its purchases. In the U.S., fashion trends have worked against polyester in some uses as other fibers and leather gained in favor. At the same time, a decline in the cotton price has led to less use of polyester in blends.

Industry sources say there is no strong prospect for an upturn in fiber demand for polyester in 1983. But further decline also seems unlikely.

Any growth in *p*-xylene demand will come in two smaller uses—film and containers. Film use has been disappointing during much of 1982, but video cassette growth could add 100 million lb to *p*-xylene demand in 1983.

Container use of *p*-xylene almost surely will be up again in 1983, but growth will be slower than in 1982 unless the new 1-L bottles catch on fast. Such an upsurge is not expected earlier than the second half. At the moment, test marketing continues for 1-L and other smaller-sized bottles for soft drinks, other beverages, and food. Even with slower growth, bottles easily will add 100 million lb and possibly 200 million lb to *p*-xylene demand in 1983.

However, even with this bright new market in bottles, *p*-xylene can't overcome the continuing drag in the fibers business. After a decade of trouble, which analysts thought had effectively adjusted polyester fiber plant capacity and prices, polyester hit another unexpected shock this year. *p*-Xylene could not escape the results and will have to endure a renewed shakeout downstream.